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THE MACRO- AND MEIOBENTHOS OF SOUTHEASTERN LAKE MICHIGAN NEAR THE MOUTH OF THE GRAND RIVER, 1976-77

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THE MACRO- AND MEIOBENTHOS OF SOUTHEASTERN LAKE MICHIGAN NEAR THE MOUTH OF THE GRAND RIVER, 1976-77*

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This report presents in detail the methods and basic results of a benthic survey designed to determine the abundance and biomass of both the macro- and meiobenthos of southeastern Lake Michigan. Sediment cores were collected at monthly intervals from May to November 1976 and 1977 by divers using SCUBA. Sampling depths were 11, 17, and 23 m. Organisms retained in screens with aperture openings of 595 µm, 106 µm, and 45 µm were counted and identified to the lowest taxonomic level possible.

Results are presented as a series of tables giving the following data: (1) mean number of organisms per square meter, (2) actual number of organisms per replicate core, (3) mean dry-weight biomass in grams per square meter, (4) actual dry weight per replicate core, and (5) vertical distribution of organisms per replicate core (1976 only).

1. INTRODUCTION

This report presents data from the first Great Lakes benthic survey to truly quantify, in terms of abundance and biomass, both the macro- and meiobenthos. Most previous benthic studies have been concerned with the larger invertebrates or those retained on a screen with aperture openings of about 500-600 µm ("macrobenthos"). The smaller forms, i.e., those that pass this size screen ("meiobenthos"), such as nematodes, copepods, cladocerans, and harpacticoids, have been largely ignored. In view of the accumulating evidence of the importance of these smaller forms in the overall dynamics of the benthic marine system (McIntyre, 1969; Gerlach, 1971, 1978), there is a basic need for quantifying these forms in the Great Lakes.

The purpose of this report is to present the data in their most basic form. No attempt is made at interpretation. Subsequent papers will summarize and discuss the data presented here. Results are given as a series of tables on taxonomic composition, numerical abundance, dry-weight biomass, and vertical distribution.

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1.1 Description of Study Site

The study area was located in southeastern Lake Michigan near the mouth of the Grand River (fig. 1). The Grand River is the largest river in Michigan, having a drainage basin of about 15,000 km^2. Sixty-nine communities, with a total population of about 685,000, discharge wastes into the basin's waters. The water quality of the lower 3.2 km (2 mi) is substandard as a result of discharges from the city of Grand Haven, Mich., at the river's mouth, and the villages of Ferrysburg and Springlake, Mich., just above the mouth (Great Lakes Basin Commission, 1975). Mean discharge into the lake is about 95.7 m^3/s, which amounts to 13 percent of the total mean discharge of all Lake Michigan tributaries. Loading of suspended solids is about 1.2 x 10^8 kg/yr. The river plume is relatively small in extent, rarely exceeding an area of 10 km^2. Although plume direction is primarily northerly, corresponding to the dominant counterclockwise circulation of the Lake Michigan Basin, it is highly dependent on wind direction and a southerly direction is not uncommon.

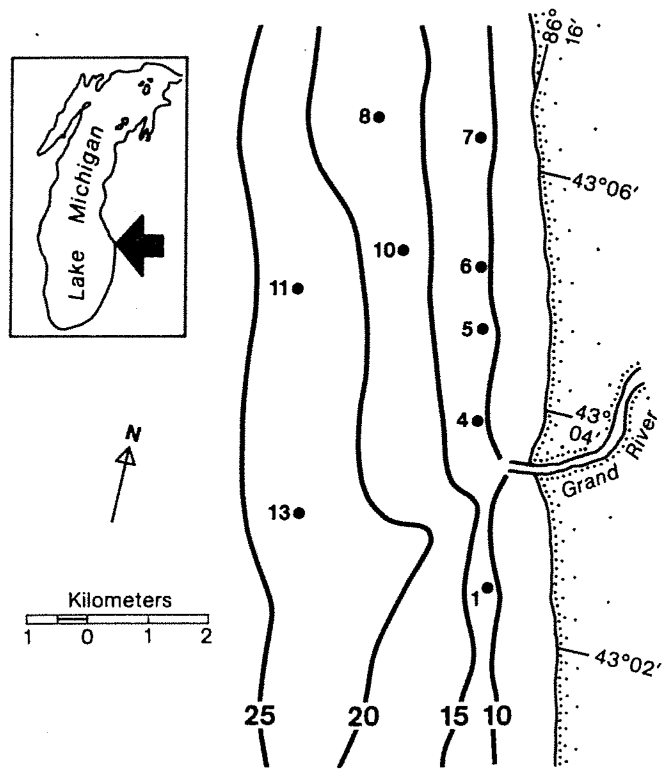

Figure 1.--*Location of sampling stations in southeastern Lake Michigan. Depth contours in meters.*

Lake Michigan bottom sediments in the area studied consist of fine, ripple-marked, beach sand at the shallow depths (11 and 17 m) and coarse, flatter sand at the deeper depth (23 m). The area was characterized by a flocculent detrital material that occurred as a layer over the surface of the sandy substrate. Accumulations of this material generally decreased as depth increased. At the shallowest depth its distribution was patchy by nature, while at the deepest depth it occurred as an even, thin veneer. There was clearly a seasonal trend in its occurrence. Accumulations were greatest in the spring, had declined by late summer, and were gone by late fall.

2. METHODS

2.1 Field

Nine stations were located parallel to the shoreline in relation to the primary direction of the Grand River plume (fig. 1). A buoy marked the location of each station; the exact positions and depths are given in table 1. Samples were collected at monthly intervals from May to November in 1976 and again in 1977. Two stations were sampled in April 1976. Not all stations were sampled on some sampling dates because of adverse weather conditions. By design, all nine stations were sampled in 1976, while sampling was limited to only four stations (stations 4, 7, 10, and 11) in 1977 (table 2).

Table 1.--*Depth and location of sampling stations in southeastern Lake Michigan*

Station No.	Depth (meters)	North latitude	West longitude
1	11	43°02'18"	86°15'06"
4	11	43°03'48"	86°16'00"
5	11	43°04'36"	86°16'15"
6	11	43°05'00"	86°16'15"
7	11	43°06'18"	86°17'00"
8	17	43°06'00"	86°18'00"
10	17	43°05'12"	86°17'30"
11	23	43°04'42"	86°18'15"
13	23	43°02'30"	86°17'30"

Sediment samples were obtained by divers using SCUBA. Four cores were generally taken at each station on each sampling date. A clear, plastic tube, 23 cm long and 5 cm in diameter, was forced into the sediment to a mean penetration of about 11 cm, stoppered at both ends, and placed upright in a plastic carrying basket. Divers moved about 4 m between each replicate core to insure an undisturbed sediment sample. The samples were brought to the surface, the water above the sediment core was immediately decanted, and then the amount of surface detritus and the depth of the oxidized layer were recorded. The oxidized material was characteristically a light brown and reduced material a light to dark grey. The cores were packed in dry ice and, after being frozen, were sliced at centimeter intervals down to a depth of 3 cm. The next section was sliced from 3 cm to the maximum depth of the oxidized layer and was followed by another interval that extended from the beginning of the reduced layer (end of the oxidized layer) to the end of the core. If the oxidized layer extended the entire length of the core, the last two sections were arbitrarily set at 3-5 cm and >5 cm. In cores where two

Table 2.--*Sampling dates and stations sampled*

Date	Station 1	4	5	6	7	8	10	11	13
Apr. 16, 1976	X				X				
May 17-19, 1976	X	X	X	X	X	X	X	X	X
June 23-25,1976	X	X	X	X	X	X	X	X	X
Aug. 2-4, 1976		X		X	X	X	X		
Aug. 24-26, 1976	X	X	X	X	X	X	X	X	X
Sept. 22-24, 1976		X	X	X	X	X	X	X	X
Oct. 13-14 and 26, 1976	X	X			X	X	X	X	X
Nov. 16, 1976							X	X	
May 2-3, 1977		X			X		X	X	
June 3, 1977		X			X		X	X	
July 11, 1977		X			X		X	X	
Aug. 8-9, 1977		X			X		X	X	
Sept. 19-20, 1977		X			X		X	X	
Oct. 17, 1977								X	
Nov. 14, 1977		X			X		X	X	

adjacent vertical sections were not cleanly separated, the organisms were divided equally between the two sections. Only cores collected in 1976 were sectioned. All samples were preserved in 10 percent buffered formalin containing rose bengal stain.

2.2 Sample Processing

The preserved core sections were washed through screens with mesh openings of 595 μm (U.S. Standard Sieve No. 30), 106 μm (U.S. Standard Sieve No. 140), and 45 μm (U.S Standard Sieve No. 325). Since most of the substrate was retained on the 106-μm screen, the organisms retained by this screen were separated from the substrate by vigorous mixing in a sugar solution (S.G. 1.18) followed by decantation. The organisms collected were counted after each set of three decantations. After the first set, the only organisms found were nematodes. If, in the second set of decantations, the number of nematodes collected was less than 5 percent of the number collected in the first set, the decantations were terminated. If not, decantation sets were continued until the number of nematodes collected in the last set was less than 5 percent of all the nematodes collected in the previous sets. Generally, only two sets (six decantations) were needed. All organisms in a given sample were counted in a grided petri dish under 25x magnification.

All groups other than nematodes, tardigrades, turbellarians, and water mites were picked and separated for future taxonomic identification. The water collected above the sediment in each of the cores was washed through a 63 µm-mesh plankton bucket, and all the organisms retained were counted and identified.

2.3 Identification

Oligochaetes were mounted on slides and cleared in Amman's lactophenol. Species identification followed the keys and descriptions of Brinkhurst and Jamieson (1971) and Hiltunen (1967, 1973). Difficult specimens were identified by J. K. Hiltunen. Variant forms of *Limnodrilus hoffmeisteri* were noted, but tabulated as *L. hoffmeisteri*. Oligochaete fragments were not counted unless a prostomium was present. The keys of Roback (1957), Saether (1975), and Jackson (1977) were used to identify chironomids. The taxonomic notes of Mozley (1975) were used for clarifying generic complexes and uncertain nomenclature. Difficult specimens were identified by S. C. Mozley. Early instar chironomids with unrecognizable characters were designated unknown. Sphaeriidae were separated into *Pisidium* and *Sphaerium*, with no further attempt to identify the former as to species. *Sphaerium* specimens consisted almost entirely of *S. nitidum*, although some specimens of *S. transversum*, *S. striatinum*, and *S. corneum* were noted. This genus was tabulated as *Sphaerium* spp. because of the large number of very small forms on which species identification could not be made with certainty. Copepods and cladocerans were identified with the keys of Wilson and Yeatman (1959), Brooks (1959), and Deevey and Deevey (1971). Cladoceran forms recognized as *Alona costata*, *Alona quadrangularis*, and *Alona guttata* were combined and tabulated as *Alona* spp. Taxonomic separation of turbellarians was not attempted since these forms must be relaxed before preservation for proper identification. However, most appeared to be *Gyratrix hermaphroditus*. Rotifers were identified with the key of Edmondson (1959). Ostracods are given only as total number, but have been saved for future species classification.

It should be noted that, for North America, the designation *Pontoporeia affinis* Lindstrom has been changed to *Pontoporeia hoyi* Smith (Segerstrale, 1977). Since this change occurred after this survey began, the use of the former designation was continued. Subsequent papers based on these data, however, will use the proper designation.

2.4 Biomass

Organism dry weights were determined by weighing on a Cahn 4100 Electrobalance (sensitivity = 0.2 µg) after the organisms were oven-dried at 70°C for 24 h and then cooled in a dessicator at room temperature. The organisms were washed in distilled water and placed on preweighed tin foil planchets before being dried. Chironomids and some of the larger organisms were weighed individually, but most organisms were weighed in groups to achieve at least a 5-µg change on the balance scale. Dryings and weighings were done in nine-planchet lots. An empty planchet in each lot was included as a check on balance drift.

Since certain benthic groups (Oligochaeta, Chironomidae, Amphipoda) are known to lose weight on preservation with formalin (Johnson and Brinkhurst, 1971; Howmiller, 1972), dry weights of these organisms were calculated from length-weight relationships. Oligochaetes and all oligochaete fragments, having been mounted on slides for identification, were placed on an overhead projector and the projected image traced onto a piece of paper. The length was then measured with a wheeled map measurer (Edmondson and Winberg, 1971; Erman and Erman, 1975). Total oligochaete length was thus obtained for each core section and screen size. A mean dry weight per unit length for each screen size was obtained from freshly killed specimens. This mean was then used to convert length to dry weight for oligochaetes in the core sections. The use of length in this way is based on the observation by Erman and Erman (1975) that preservation does not alter length.

Length-weight relationships for most of the abundant species of chironomids were calculated from individuals that were either freshly killed or preserved in formalin. Dry weights obtained from formalin preserved individuals were corrected for weight loss by multiplying the measured dry weights by 1.65. This factor, the ratio of fresh weight to preserved weight, is a mean of 1.58 (Howmiller, 1972) and 1.71 (Johnson and Brinkhurst, 1971). Less abundant chironomid species were assigned the length-weight relation of a closely related, more abundant form. The total body lengths and head capsule widths of all chironomids in the samples were measured with an ocular micrometer. The length-weight relationships for *Pontoporeia affinis* and *Gammarus fasciatus* were taken from Johnson and Brinkhurst (1971), with an 80 percent correction factor for converting ash-free dry weight back to dry weight. The telson-rostrum length of these forms was measured after they were straightened slightly with a pair of dissecting needles. The Sphaeriidae were separated into three arbitrary size classes and a mean dry weight determined for each. Dry weights of the Sphaeriidae, Gastropoda, and Ostracoda were determined by subtracting the weight after ashing at 550°C for 1 h from the oven-dried weight. Dry weights for these groups is thus the shell-free dry weight.

Dry weights of all other forms were obtained directly from formalin preserved specimens. Weight loss due to preservation in most of these remaining forms is minimal (Dumont *et al.*, 1975). Since nematode size was highly variable, a separate mean dry weight was determined for organisms retained on each of the three screens.

The list of species collected in the sediments and their estimated dry weights are given in table 3. Those organisms for which dry weights were not measured directly were assigned dry weights of a closely related form of similar size.

Table 3.--*Species list and dry weights*

Species	Dry weight (μg)	Number weighed
Oligochaeta		
Enchytraeidae	250 per cm length	Total number collected
Lumbriculidae	for those oligochaetes retained	in about 16 cores in
Stylodrilus heringianus	in 595-μm screen	July and August 1976.
		Each core considered
Tubificidae		one replicate.
Aulodrilus limnobius	60 per cm length	
A. pluriseta	for those olegochaetes retained	
Limnodrilus augustipenis	in 106-μm screen	
L. cervix		
L. claparedeianus		
L. hoffmeisteri		
L. profundicola		
L. udekemianus		
Peloscolex ferox		
P. freyi		
P. multisetosus multisetosus		
P. multisetosus longidentus		
P. superiorensis		
Potamothrix moldaviensis		
P. vejdovskyi		
Rhyacodrilus coccineus		
Naididae		
Amphichaeta sp.		
Chaetogaster diaphanus		
Chaetogaster sp.		
Nais behningi		
Nais bretscheri		
N. elinguis		
N. pardalis		
Nais sp.		
Ophidonais serpentia		
Paranais frici		
Piguetiella michiganensis		
Pristina longiseta leidyi		
Slavina appendiculata		
Stylaria lacustris		
Uncinais uncinata		
Vejdovskyella intermedia		
Hirudinea	combination of species = 712.6	6
Erpobdellidae		
Glossiphoniidae		
Helobdella stagnalis		

Table 3.--*Species list and dry weights (con.)*

Amphipoda		
Gammaridae	$\log w = -4.264 + 2.444 \log L$	Johnson and Brinkhurst
Gammarus fasciatus	(wt in mg)	(1971)
Haustoriidae		
Pontoporeia affinis	$\log W = -4.297 + 2.55 \log L$	Johnson and Brinkhurst
	(wt in mg)	(1971)
Gastropoda		
Hydrobiidae		
Amnicola sp.		
Bythinia tentaculata		
Physidae		
Physa sp.		
Valvatidae		
Valvata sincera	662.3	7
V. tricarinata		
Pelecypoda	Sphaeriidae small: 51.5	20
Sphaeriidae	Sphaeriidae medium: 94.2	25
Pisidium spp.	*Pisidium* large: 261.4	7
Sphaerium spp.	*Sphaerium* large: 2,061.3	4
Diptera		
Ceratopogonidae		
Chironomidae		
Chironomus anthracinus - gr.		
C. fluviatilis - gr.	$\log W = .0359 + 2.8444 \log L$ ($r = 0.98$)	18
C. w/o bloodgills	(length in mm)	
Chironomus sp.		
Cryptochironomus digitatus		
C. fulvus -gr.		
Cladotanytarsus sp.	$\log W = 0.1557 + 3.1419 \log L$ ($r = 0.94$)	13
Harnischia sp.		
Heterotrissocladius changi	$\log W = 0.8129 + 2.1946 \log L$ ($r = 0.87$)	18
H. oliveri		
Micropsectra sp.		
Monodiamesa tuberculata	$\log W = 0.7460 + 2.661 \log L$ ($r = 0.98$)	11
Parachironomus demeijerei	$\log W = 0.0800 + 2.2817 \log L$ ($r = 0.96$)	4
Paracladopelma udine	$\log W = 0.9879 + 2.4456 \log L$ ($r = 0.92$)	19
P. winnelli		
Paracladopelma sp.		
Polypedilum fallax	$\log W = -0.2712 + 3.0414 \log L$ ($r = 0.99$)	4
P. scalaeum	$\log W = 1.0890 + 2.3190 \log L$ ($r = 0.99$)	7
Potthastia cf. *longimanus*		
Procladius sp.		
Psectrocladius simulans	$\log W = 0.5524 + 2.7083 \log L$ ($r = 0.88$)	13
Psectrocladius sp.		
Saetheria tylus	$\log W = 0.7797 + 2.6474 \log L$ ($r = 0.98$)	10
Tanytarsus sp.		
Copepoda		
Cyclopoida		
Copepodid I	0.6	27
C. II	0.7	43
C. III	1.2	31

C. IV		1.9	41
C. V		2.6	29
Cyclops bicuspidatus thomasi		♀ = 4.2; ♂ = 1.7	30; 20
C. vernalis		♀ = 9.9; ♂ = 2.7	25; 25
Eucyclops agilis		4.6	6
Mesocyclops edax			
Paracyclops fimbriatus poppei		3.6	17
Tropocyclops prasinus mexicanus		0.9	50
Calanoida			
Copepodid III			
C. V			
Eurytemora affinis		4.3	26
Epischura lacustris			
Limnocalanus macrurus			
Harpacticoida			
Copepodid I	$\bar{X}$ of Copepodid I and II =	0.4	6
C. II			
C. III		0.6	3
C. IV		0.8	7
C. V		1.5	6
Attheyella cf. nordenskioldii			
Bryocamptus nivalis	$\bar{X}$ of *B. nivalis* and *B. cf.*		
B. cf. vejdovskyi	*vejdovskyi*:	♀ = 1.7; ♂ = 1.3	10; 13
Canthocamptus robertcokeri		♀ = 3.2; ♂ = 2.2	21; 6
C. staphylinoides		♀ = 5.0; ♂ = 4.1	7; 6
Moraria cristata			
Parastenocaris spp.		0.6	13
Cladocera			
Alona affinis		6.8	37
Alona spp.		4.3	10
Alonella sp.			
Bosmina longirostris		0.8	36
Chydorus sphaericus		1.2	32
Daphnia retrocurva			
Eubosmina coregoni			
Eurycercus lamellatus		11.1	31
Ilyocryptus acutifrons	*Ilyocryptus* spp.=	3.9	28
I. sordidus			
Latona setifera			
Leydigia quadrangularis		2.8	10
Macrothrix laticornis			
Ostracoda		21.2	13
Nematoda	those retained in 595-µm screen =	22.5	112
	those retained in 106-µm screen =	0.5	655
	those retained in 45-µm screen =	0.1	350
Tardigrada		0.3	368
Turbellaria		3.5	13
Rotifera	combination of species =	0.2	52
Dircranophoridae			
Philodinidae			
Dissotrichia sp.			
Coelenterata			
Hydra americana			
Hydracarina			

3. EXPLANATION OF TABLES 4-8

Table 4 (on microfiche in inside back cover) gives abundance as the mean number per square meter at each station on each sampling date, and table 5 (on microfiche in inside back cover) gives abundance as the actual number collected in each replicate core on each sampling date. The replicate cores within a given station were designated A, B, C, and D. The abundance of each taxon for each station in table 4 represents the mean of the 4 (sometimes 3 or 5) replicates per station shown in table 5 divided by a conversion factor of 0.002 to obtain the number per square meter. Concerning the tabulation of *Canthocamptus* cysts, in table 5 the encysted individuals are given separately and in table 4 they are combined with the appropriate species and sex. Table 6 (on microfiche in inside back cover) gives the mean dry-weight biomass in grams per square meter for each station on each sampling date, and table 7 (on microfiche in inside backcover) gives the dry-weight biomass in milligrams for each replicate core on each sampling date.

The vertical distribution of selected species or species groups in each of the replicate cores is presented in table 8 (on microfiche in inside back cover). The vertical intervals for each core are given (in centimeters) just to the right of each station number. The number or letter in parentheses to the left of each 0-1-cm interval gives the amount (in centimeters) of detritus found on the surface of that core with N = none and T = present but in trace amounts. The last vertical interval in each core consists entirely of unoxidized material, except the last interval in cores marked by the symbol +. In these cores, oxidized material was evident the entire length of the core. The organisms in this table were coded as follows: E. = Enchytraeidae; S.h. = *Stylodrilus heringianus;* Im. = immature Tubificidae without hair setae; O.t. = other Tubificidae; N. = Naididae; P. a. = *Pontoporeia affinis;* G. = Gastropoda; P. = Pelecypoda; Ch. = Chironomidae; J. C. = juvenile Cyclopoida (I-V); A. C. = adult Cyclopoida; J. H. = juvenile Harpacticoida (I-V); A. H. = adult Harpacticoida; Cl. = Cladocera; Os. = Ostracoda; Nem. = Nematoda; T. = Tardigrada; Tu. = Turbellaria; R. = Rotifera. As a further clarification of the vertical distribution of harpacticoids, this group was separated into two additional categories. The number in parentheses next to the total number of adult harpacticoids in an interval gives the number of those adults that were encysted and an asterisk (*) denotes those harpacticoids (either adults or copepodids) that are of the genus *Parastenocaris,* a form known to inhabit subterranean environments.

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